

Article

Nomenclatural changes in *Anastatus* Motschulsky and the description of *Anastatus eurycanthalae* Gibson n. sp. (Eupelmidae: Eupelminae), an egg parasitoid of *Eurycantha calcarata* Lucas (Phasmida: Phasmatidae) from Papua New Guinea

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Abstract

Anastatus eurycanthalae Gibson n. sp. (Eupelmidae: Eupelminae) is newly described as an egg parasitoid of *Eurycantha calcarata* Lucas (Phasmida: Phasmatidae), an important pest of oil palm in Papua New Guinea. Both sexes are described and illustrated by macrophotography and scanning electron microscopy. Basic biological data are provided on the parasitoid. Six species are transferred from *A. (Anastatus)* Motschulsky to other genera, namely *Eupelmus tennysoni* Girault (1921) revived comb., *Eupelmus (Eupelmus) darwini* (Girault 1915) n. comb., *Reikosiella (Hirticauda) pasteuri* (Girault 1915) n. comb., *R. (Hirticauda) tricolor* (Girault 1915) n. comb., *Tineobius (Tineobius) adamsi* (Yoshimoto & Ishii 1965) n. comb., and *T. (Tineobius) crassipes* (Yoshimoto & Ishii 1965) n. comb.

Key words: Giant Spiny Stick Insect, oil palm pest

Introduction

Eurycantha calcarata Lucas (1869) (Phasmida: Phasmatidae), the Giant Spiny Stick Insect (Brock 1992, 1999), was described originally from the Solomon Islands. It is also recorded from New Caledonia (Hsiung 1985, 1987) and the Bismarck Archipelago (New Britain and New Ireland provinces) of Papua New Guinea (PNGOPRA 1990). Sharp (1898) recorded it from northern Australia, but this latter record was refuted by Monteith & Dewhurst (2011). It is an important pest of oil palm in Papua New Guinea, particularly among smallholder growers and in plantations that are near to natural forest. Although it does not fly, its distribution indicates it disperses effectively across both land and water. Females of the parasitoid described here likewise do not fly, but it is the only species we have found in West New Britain that from laboratory studies seems to effectively parasitize eggs of the Giant Spiny Stick Insect. It is now being reared in the laboratory for field release as part of ongoing applied research into IPM control methodologies, particularly using natural enemies, for management of the pest.

The only eupelmids previously reported as parasitoids of stick insects are *Paranastatus nigriscutellatus* Eady (1956) and *P. verticalis* Eady (1956) from *Graeffea crouanii* (Le Guillou) in Fiji, and *Anastatus gratidiae* Risbec (1951) from *Gratidia* sp. in Senegal (Noyes 2011). Species of *Anastatus* Motschulsky (Eupelmidae: Eupelminae) are mostly primary endoparasitoids of a wide diversity of insect eggs, though some have been reared as hyperparasitoids (Gibson 1995). Noyes (2011) listed 39 species of *Anastatus* from the Australasian region, including 33 species from Australia, but none from New Guinea. Six of the species are incorrectly assigned to genus and males are recognized for only four of the remaining 33 species. Like other genera of Eupelminae, the sexes of *Anastatus* are strongly dimorphic (*cf.* Figs 1, 2 with 8, 9) and taxonomy of the genus is based entirely on females (Gibson 1995). Comparison of females reared from *E. calcarata* with the original descriptions of the 33 true species of *Anastatus* from the Australasian region indicates they represent a new species.

Material and methods

Type specimens were reared in the Papua New Guinea Oil Palm Research Association (PNGOPRA) laboratory from a colony established originally from a few individuals reared from eggs of *E. calcarata*. These were collected in the field from New Britain Palm Oil, Malilimi Plantation on West New Britain, Papua New Guinea, in June 2007. Reared individuals were sent in ethanol to the senior author and were then critical-point dried, point-mounted, and examined using a halogen light source and a Nikon SMZ-U microscope fitted with a 10 mm ocular grid having 100 divisions. A piece of translucent Mylar tracing acetate was taped to the objective between the light source and specimen to reduce glare. Scanning electron photomicrographs of uncoated specimens were obtained with a Philips XL30 environmental scanning microscope. Photomacrographs were obtained with a Leica DC500 digital camera attached to a Leica Z16 APO macroscope. Antennae were cleared and slide-mounted for images, which results in a lighter-coloured flagellum with more obvious multiporous plate sensilla (mps) (Figs 14, 15) than observed in point-mounted individuals (*cf.* Figs 9, 15). The serial digital images were combined with AutoMontage or CombineZP and digitally retouched using Adobe Photoshop to enhance clarity. Paratypes used for imaging are designated with “CNC Photo 2011-x” numbers, which are cited in the figure captions. Morphological terms follow Gibson (1995, 1997). The ocular ocellar line (OOL) is the minimum distance between a posterior ocellus and an eye, whereas the posterior ocellar line (POL) is the minimum distance between the posterior ocelli, and the lateral ocellar line (LOL) is the minimum distance between a posterior and anterior ocellus. These lengths are compared with the maximum diameter of the posterior ocellus (MDPO).

Comparison of females of the new species with those of previously described species of *Anastatus* from Australia is based on the original descriptions and notes taken on type material in QMBA by the senior author in 1999. The senior author also examined holotypes of the species described in *Anastatus* by Yoshimoto & Ishii (1965) housed in the Bernice P. Bishop Museum, Honolulu, HI, USA (BPBM) and in the USNM. Type specimens of the new species are deposited in the following museums:

ANIC	Australian National Insect Collection, Canberra, ACT, Australia.
BMNH	The Natural History Museum, Department of Entomology, London, England.
CNC	Canadian National Collection of Insects, Arachnids and Nematodes, Agriculture and Agri-Food Canada, Ottawa, ON, Canada.
NIC	National Insect Collection Kilakila, Port Moresby, Papua New Guinea.
PNGOPRA	PNG-Oil Palm Research Association, Dami Research Association, West New Britain, Papua New Guinea.
QMBA	Queensland Museum, Brisbane, QLD, Australia.
USNM	United States National Entomological Collection, U.S. National Museum of Natural History, Washington, DC, USA.

Australasian species removed from *Anastatus* Motschulsky

Eupelmus (Eupelmus) darwini (Girault) n. comb.

Anastatus darwini Girault, 1915: 24–25. Type data: Australia: Queensland, Brisbane. Syntype female (QMBA). Described: female.

Remarks. This species was described originally from two females, but only a single syntype remains on a card. The specimen lacks its head, but crushed parts of the head and an antenna are on a slide (Dahms 1983).

Eupelmus tennysoni Girault revived comb.

Eupelmus tennysoni Girault, 1921: 188. Type data: Australia: Queensland, Nelson. Holotype female (QMBA, missing). Described: female.

Anastatus tennysoni; Bouček, 1988: 552. Change of combination.

Remarks. Girault (1921) did not state the number of specimens on which *E. tennysoni* was based, but the original description gives no indication that there was more than one female. Dahms (1986) did not locate the holotype, but did refer to a single female of *Anastatus* in the QMBA that is labelled as a paratype of *E. tennysoni*. Although Dahms suggested that this female likely was not part of the type series, it is undoubtedly the reason why Bouček (1988) transferred *E. tennysoni* to *Anastatus*. However, the putative paratype cannot be part of the type series of *E. tennysoni* because Girault stated that the ovipositor sheaths were “nearly as long as abdomen”. The purported paratype female, like most female *Anastatus*, has the ovipositor sheaths projecting only slightly beyond the apex of the metasoma. Based on Girault's original description, *E. tennysoni* belongs to *Eupelmus* and, mostly likely, to *E. (Episolinella)*. When Girault (1921) described *E. tennysoni* he stated that it was like *E. dumasi* Girault (1915), which he had previously described as being similar in all respects to *E. renami* Girault (1915). As part of the latter description he stated that the extruded valves of the ovipositor were concolorous. Females of *E. (Episolinella)* commonly have uniformly coloured ovipositor sheaths, whereas those of *E. (Eupelmus)* more commonly have banded ovipositor sheaths. Dahms (1986) also listed a slide that is labelled as a paratype of *E. tennysoni* Girault, which contains one antenna and a fore wing from a missing specimen. The fore wing has a linea calva, which confirms placement of the species in *Eupelmus* if the slide was made from the holotype of *E. tennysoni*. However, the parts remaining are insufficient to confidently establish subgeneric placement.

Reikosiella (Hirticauda) pastouri (Girault) n. comb.

Anastatus pastouri Girault, 1915: 24. Type data: Australia: Queensland, Cloncurry. Holotype female (QMBA). Described: female.

Remarks. The holotype consists of a card-mounted female and a slide with the crushed head and one antenna, fore wing and leg (Dahms 1986).

Reikosiella (Hirticauda) tricolor (Girault) n. comb.

Anastatus tricolor Girault, 1915: 22–23. Type data: Australia: Queensland, Gordonvale (Cairns). Holotype female (QMBA).

Described: female.

Eupelmus tricolor; Girault, 1924: 1. Combination by inference through listing of specific epithet under *Eupelmus atriflagellum* Girault.

Remarks. Only parts of the ovipositor and of a leg of the holotype remain (Dahms 1986). The parts are insufficient to establish correct generic classification, but Girault's description is sufficient to place this species as a member of *R. (Hirticauda)*. The antenna was described as having the apex of the scape, pedicel and f11 reddish yellow, and f12–f15 silvery white. A flagellum with some white segments is characteristic of species of *R. (Hirticauda)*. Girault also described the scape as “swollen at base”, and the “marginal vein much longer than the submarginal”, which are also characteristic of females of many *Reikosiella* species. The description is sufficiently detailed that the species should be readily recognizable within the Australian fauna.

Tineobius (Tineobius) adamsi (Yoshimoto & Ishii) n. comb.

Anastatus adamsi Yoshimoto & Ishii, 1965: 159. Type data: Caroline Is.: Ponape I., Net Point. Holotype female (USNM).

Described: female.

Remarks. Yoshimoto & Ishii (1965, figs 24a, b) provided line drawing habitus images of the female.

***Tineobius (Tineobius) crassipes* (Yoshimoto & Ishii) n. comb.**

Anastatus crassipes Yoshimoto & Ishii, 1965: 156–158. Type data: Caroline Is.: Palau Is., Koror. Holotype female (BPBM). Described: female.

Remarks. Yoshimoto & Ishii (1965, figs 23b, c) provided line drawing habitus images of the female.

***Anastatus* Motschulsky 1859**

Remarks. See Gibson (1995) for extensive generic synonymy, description of the genus and its two component subgenera, and a key to identify females and males of *Anastatus* from other world Eupelminae. Girault (1915) provided a key to females of most described Australian *Anastatus*.

A. (*Anastatus*) *eurycanthea* Gibson n. sp.

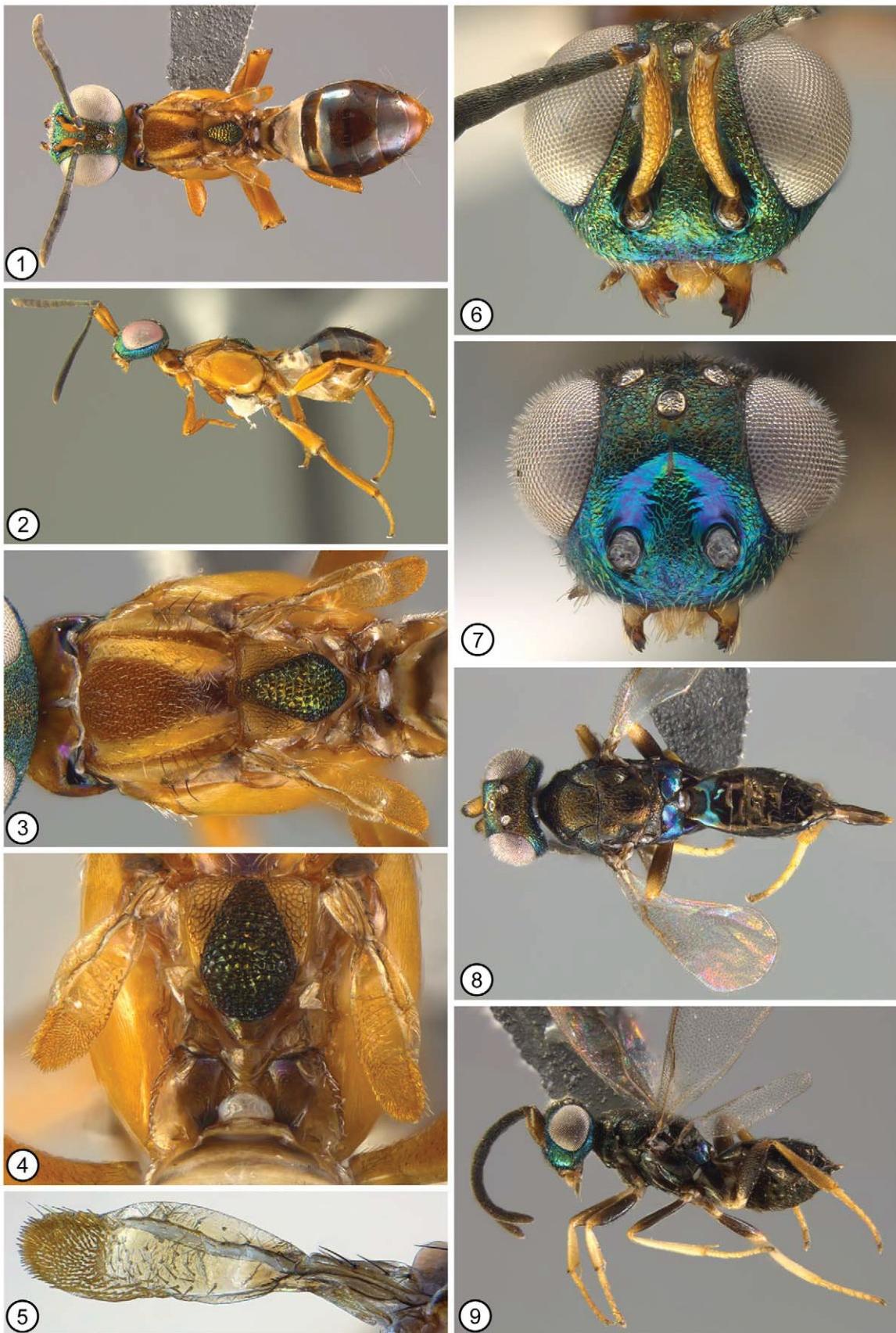
Figs 1–16

Type material. HOLOTYPE (♀, BMNH). PAPUA NEW GUINEA, West New Britain Prov., Dami Research Station, ex lab reared *E. calcarata* egg, em. 7.xii.2011, S. Makai / Holotype *A. (Anastatus) eurycanthea* Gibson, 2012. ALLOTYPES (♂, BMNH). Same collection data as holotype.

PARATYPES. Same data as holotype (83♀, 53♂); same data as holotype except collected 6.vi.2011 (19♀, 9♂; 1♀ with egg case glued on card); same data as holotype except collected 6.vi.2011, emerged 7.vi.2011 (40♀, 9♂; 1♀ with egg case glued on card); same data as holotype except 12.xi.2011 (11♀, 1♂). Paratypes deposited in ANIC, BMNH, CNC, QMBA, USNM.

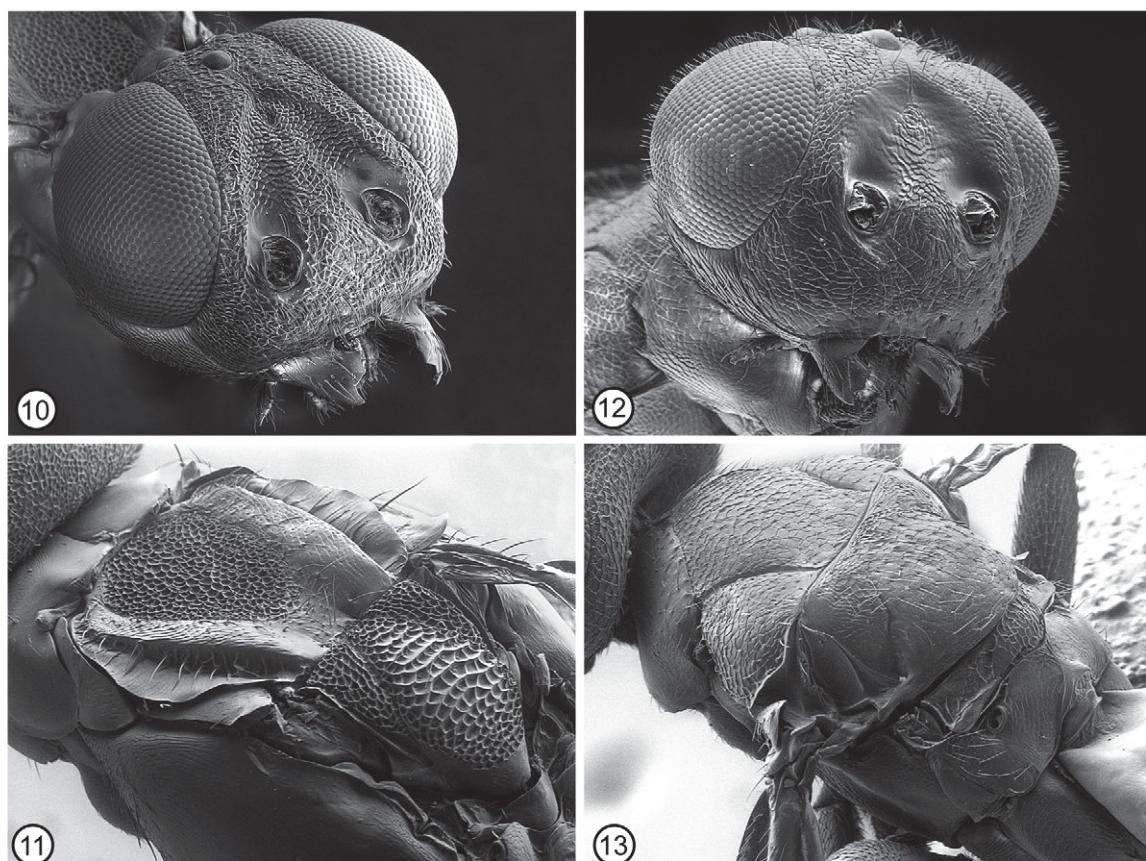
Etymology. Named after the host genus, *Euryantha*.

Description. FEMALE (Figs 1, 2). Length, about 2.5–3.2 mm. Head bright metallic green (Fig. 6) except with diffuse coppery lustre on frontovertex (Fig. 1), usually blue to purple along posterior orbit and sometimes on lower face, and clypeus yellowish-brown; palpi yellowish to dark brown; setae mostly white except some dark on vertex and along inner orbit, and hairlike except with denser, flattened, elongate-lanceolate, translucent setae on lower face, interantennal area between toruli, and parascrobal region ventrally; frons very shallowly meshlike reticulate-coriaceous, vertex somewhat more coarsely punctulate-reticulate, parascrobal region rugulose-roughened dorsally to rugulose-reticulate ventrally, interantennal region and scrobes transversely strigose-imbricate to granular dorsally, and interantennal region ventrally between scrobes more finely coriaceous-imbricate (Fig. 10). Head in frontal view (Fig. 6) about 1.4× wider than high; width in dorsal view about 3.6× minimum distance between eyes; face with V-like scrobal depression extended to within about 1.4 ocellar diameters of median ocellus (Fig. 10), but usually connected to ocellus by variably distinct, vertical band of differentiated sculpture, and separated from inner orbit ventrally by slightly less than ocellar diameter; lower orbit in line with about middle of torulus; distance between toruli about 2× torular diameter; distance between torulus and oral margin about 1.8× torular diameter; interantennal area convex ventrally between toruli but flattened dorsally. Head in dorsal view with OOL: POL: LOL: MDPO about 0.6: 1.5: 1.2: 1.0; vertex comparatively long and low convex, with distance between posterior ocelli and occipital margin only slightly less than minimum distance between eyes, and temple about 0.4× minimum distance between eyes. Head with malar sulcus; in lateral view malar space almost 0.4× eye height. Eye white to pink, glabrous (Fig. 6), about 1.3× as high as long. Mandible (Fig. 6) yellowish basally to more reddish subapically and black apically; indistinctly tridentate, the incision between lower and middle tooth deeper and much broader than between middle and upper tooth. Antenna (Fig. 14) dark brown except scape yellowish with slight darkening at extreme apex; scape (excluding radicle) about 5× as long as wide; pedicel about 1.7× as long as wide; first flagellomere (fl1 = anellus), fl2 and sometimes fl3 lacking mps, but subsequent flagellomeres with increasingly more numerous mps; relative length (width) measurements of pedicel: fl1–fl8: clava about 17(10): 9(9): 21(10): 22(12): 23(14): 21(14): 19(15): 17(15): 17(15): 454(15).



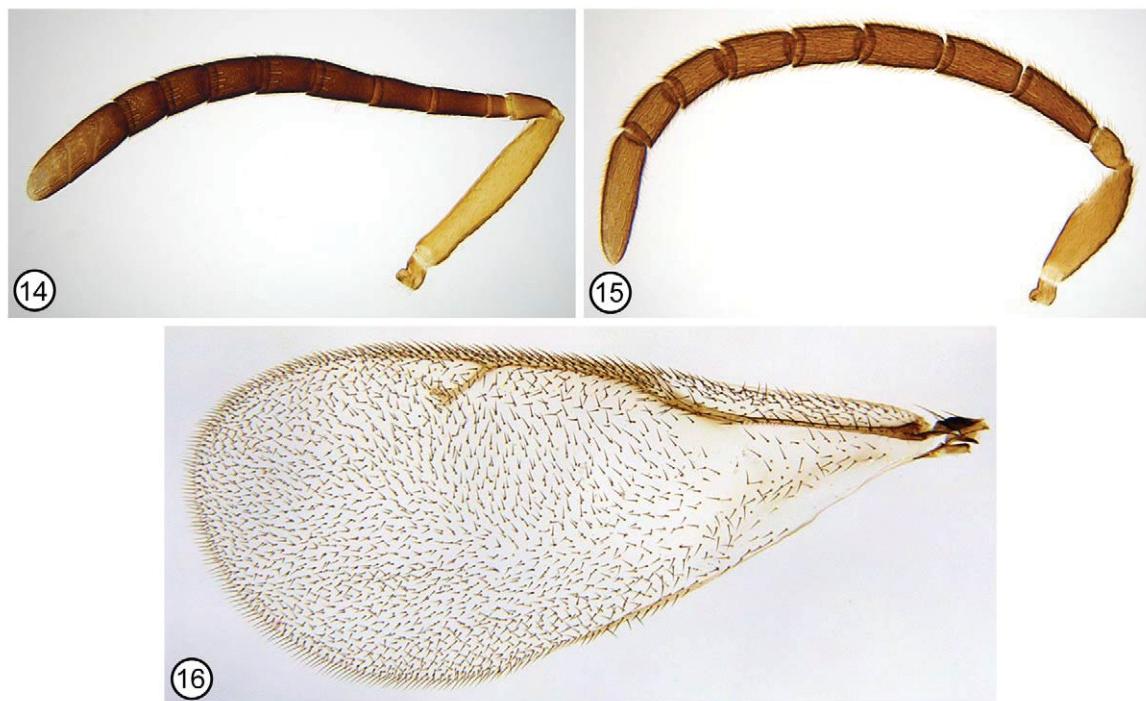
FIGURES 1–9. *Anastatus eurycantheae* Gibson. 1, ♀ dorsal habitus (2011-74); 2, ♀ lateral habitus (2011-75); 3, ♀ dorsal mesosoma (2011-75); 4, ♀ scutellar-axillar complex and propodeum (2011-74); 5, ♀ fore wing (2011-77); 6, ♀ head, frontal view (2011-74); 7, ♂ head, frontal view (2011-81); 8, ♂ dorsal habitus (2011-80); 9, ♂ lateral habitus (2011-79).

Mesosoma mostly yellowish-orange (Figs 1–4) but pronotum with emarginate margin anterior to spiracle black and collar mesally and/or laterally sometimes variably extensively brown; mesoscutum mesal to inclined lateral surfaces orange to dark brown; scutellum dark brown to metallic green; tegula at least apically, axilla often partly, and acropleuron anteriorly sometimes brownish; and propodeum darker brown at least between spiracles. Pronotum flat, smooth, shiny, and glabrous dorsomesally, though laterally very finely coriaceous-alutaceous and with short, scattered setae, with only a single longer, conspicuous seta anterior to spiracle. Mesoscutal medial lobe (Fig. 11) almost flat anteriorly to more deeply and narrowly concave posteriorly relative to inclined lateral lobes, meshlike reticulate with white, hairlike setae; lateral lobe with inclined inner surface shiny, superficially smooth or only very finely coriaceous-imbricate and broadened posteriorly, and both inner and outer surfaces with a line of long, dark setae. Axilla (Figs 4, 11) meshlike reticulate, with a line of dark setae laterally. Scutellum (Figs 4, 11) deeply reticulate-umbilicate to transversely umbilicate-crenulate except indistinctly delineated frenal area punctate-reticulate, and broad marginal rim (often concealed by dorsellum) smooth to finely sculptured; with a line of dark setae along lateral margin extending posteriorly to about frenal area. Mesopleuron uniformly setose with slender white setae anterior to acropleural sulcus; acropleuron very finely alutaceous to smooth and shiny mesally. Fore wing (Figs 3–5), including basal plate, about 4.5× as long as wide, with apex rounded and extending slightly over base of gaster when directed posteriorly; basal plate with a row of 4–7 dark setae; disc, measured from base of costal cell, about 3× as long as wide, about apical one-third of disc densely setose with comparatively thick orange setae and often bent upwards slightly or at least differentiated by a furrow that is continuous to base along vannal margin, and with membrane basal to setose region with slight orange tint, the median third of disc comparatively sparsely setose with thinner setae and usually with bare spot behind submarginal vein adjacent to densely setose region, and about basal third of disc bare; costal cell extending about to base of apical setose region and bare except for a few setae ventrobasally; marginal vein extending along setose region to apex of wing, without evident stigmal or postmarginal veins. Hind wing (Fig. 4) reduced to much shorter, slender, arcuate, hyaline membrane lacking setae except for 1 or 2 terminal setae. Legs (Figs 1, 2) similar in colour to mesopleuron except metatrochanter



FIGURES 10–13. *Anastatus eurycantha* Gibson (SEM). 10, ♀ head, frntolateral view (2011-74); 11, ♀ mesonotum, dorsolateral view (2011-74); 12, ♂ head, frontolateral view (2011-81); 13, ♂ mesosoma, dorsolateral view (2011-80).

sometimes white, apical tarsomere brown, and tibial and tarsal pegs dark; protibia with 4 or 5 apical pegs; mesotibia with 2 or 3 apical pegs; basitarsus with 10–12 pegs in serrate row, the pegs of uneven length; second tarsomere with 5 or 6 pegs, third tarsomere with 2 pegs, and fourth tarsomere with single peg apically on either side; metacoxa with dense though slender band of white setae laterally. Propodeum (Fig. 4) typical for genus, setose only along extreme lateral margins and smooth and shiny or at most very finely coriaceous mesal to spiracles.



FIGURES 14–16. *Anastatus eurycanthae* Gibson (slide mounts). **14**, ♀ antenna. **15**, ♂ antenna. **16**, ♂ fore wing.

Gaster (Figs 1, 2) with syntergum yellowish-orange, otherwise mostly dark brown dorsally and lighter brown to yellowish-orange laterally except for subbasal white region, though white region not always evident in air-dried specimens with compacted terga; sterna white except hypopygium brownish apically; terga very sparsely setose, each with single transverse row of long dark setae except syntergum subbasally with 2 paramedial setae and with a row of setae near posterior margin between cerci; first gastral tergum smooth and shiny, second gastral tergum translucent, and subsequent terga finely meshlike coriaceous; syntergal flange strongly transverse, much wider than long; ovipositor sheaths not projecting.

MALE (Figs 8, 9). Length, about 1.7–2.0 mm (excluding genital capsule if protruding). Head sometimes partly dark or with coppery lustre, particularly frontovertex (Fig. 8), but with variably distinct and bright metallic blue to bluish-green lustre at least on face and gena (Figs 7, 9); labiomaxillary complex often mostly more or less white, but at least apical palpomere of maxillary palpus brown; with relatively inconspicuous, whitish, hairlike setae except dark setae on vertex and occiput; meshlike coriaceous dorsally to coriaceous-alutaceous ventrally, with interantennal region often somewhat stronger coriaceous-granular, and scrobes much smoother and shiny (Figs 7, 12); scrobal depression with variably conspicuous vertical line extending from apex of interantennal region toward anterior ocellus, but line not distinctly sulcate or light coloured (Fig. 7). Head in frontal view (Fig. 7) about 1.3× as wide as high with genae converging to oral margin, the distance across oral cavity in ventral view slightly less than 0.4× width of head; width about 2.2× minimum distance between eyes; toruli with ventral margins slightly but distinctly below ventral margin of eyes, with distance between toruli almost 1.5× distance between torulus and inner orbit and slightly less than distance between torulus and oral margin. Head in dorsal view with OOL:POL:LOL:MDPO about 0.6: 1.9: 1.1: 1.0. Eye white, conspicuously setose (Fig. 7), and subcircular though height slightly greater than length (Fig. 9). Mandible similar to female. Antenna (Fig. 15) dark brown or scape lighter brown than flagellum, but ventroapically with white, tapered region for reception of pedicel extending about

half length of scape, the region membranous (not developed as distinct microsensory region) and often partly collapsed in air-dried specimens; scape (excluding radicle) about 3× as long as wide; pedicel only slightly longer than wide; flagellum typical for genus with f11 so strongly transverse as to be superficially missing and flagellomeres otherwise comparatively thick, with dense sensilla, and dull with dense, short setae; clava about 2× length of apical funicular and with inconspicuous ventroapical microsensory region; relative length (width) measurements of f12–clava about 27(11): 23(12): 22(13): 20(12): 20(12): 16(12): 16(12): 35(11).

Mesosoma dark brown without distinct metallic lustre except propodeum usually variably distinctly blue to purple (Figs 8, 9); mesopleurosternum uniformly dark without distinctly lighter transepisternal line and setae brown ventrally, not contrasting with cuticle. Mesonotum mostly meshlike coriaceous, but median mesoscutal lobe more roughened-reticulate to shallowly rugulose anteriorly, and uniformly, densely setose with brown hairlike setae except about posterior half of scutellum more sparsely setose (Fig. 13). Front leg (Fig. 9) with coxa and femur dark brown (extreme apex of femur typically lighter brownish-yellow), but trochanter, trochantellus, tibia and tarsus yellowish-white except for slightly darker apical tarsomere; profemur with comparatively short, straight setae not contrasting conspicuously in colour with cuticle, and only sparsely setose mesolongitudinally; protibia with 2–4 dark apical spicules. Middle leg (Fig. 9) similar in colour to front leg except trochanter also brown and apex of femur usually more distinctly lighter in colour. Hind leg (Fig. 9) similar in colour to front leg except femur usually completely brown and tibia variably but usually obviously darker brown than pro- and mesotibiae. Fore wing hyaline except sometimes for slight brownish infuscation along posterior margin of basal cell (Fig. 16); with brown setae contrasting conspicuously with membrane, and uniformly setose except for vannal region and small region behind parstigma adjacent to basal fold; cc: mv: pmv: stv about 5.4: 3.2: 2.2: 1.0.

Gaster (Figs 8, 9) dark brown except first gastral tergum with variably distinct metallic blue to purple lustre; terga with brown setae. Genital capsule with single apical and subapical seta on volsella, 1 apical seta on paramere, and digitus with 2 or 3 spines.

Biology. Adults are being reared routinely from the eggs of laboratory-caged host insects. The parasitoids are fed with 10% honey and are being released in areas where populations of stick insect threaten oil palm plantings. Biological studies are continuing, but initial observations show that a mean of about 4 males and 14 females emerge from an egg, though a wide range (1–9 males and 8–20 females) of individuals can emerge from a single egg.

Remarks. Of the 33 valid species of *Anastatus* reported from the Australasian region by Noyes (2011), females of only the following eight species are brachypterous: *A. apterus* (Girault 1913), *A. flavithorax* (Girault & Dodd in Girault 1915), *A. goethei* (Girault 1929), *A. hemipterus* (Girault 1913), *A. lutheri* (Girault 1934), *A. mancus* (Girault 1915), *A. semitectus* (Girault 1915), and *A. simplicifrons* (Girault 1924). All of these species were described from Australia. Of the eight species, females of four (*A. apterus*, *A. lutheri*, *A. semitectus*, and *A. simplicifrons*) have the head and body dark brown or with a slight metallic green lustre, but *A. flavithorax*, *A. goethei*, *A. hemipterus* and *A. mancus* have the mesosoma and legs yellowish to yellowish-orange so as to be more or less similar in colour to *A. eurycanthea*. Females of *A. goethei* are readily differentiated by their densely setose eyes and gaster. The fore wings are also setose over about the basal half and are apically truncate with the submarginal vein attaining the apex (Girault 1929, Bouček 1988), and the mesoscutum has a low, slightly wavy median carina among wavy, interconnected carinulae. Females of *A. mancus* are differentiated by a smooth and shiny mesoscutum (except for a median carina), the scutellar-axillar complex being yellowish-orange similar to the mesoscutum, the fore wing being obliquely truncate with only the extreme apex recurved and setose, and the ovipositor sheaths being exerted for about half the length of the gaster. Females of both *A. flavithorax* and *A. hemipterus* differ from *A. eurycanthea* by having longer fore wings with fuscous cross bands (Girault 1913, 1915) and f11–f13 or f14 of the flagellum yellowish to yellowish-orange.

It is difficult to evaluate what combination of features should differentiate *A. eurycanthea* males because males are unrecognized for almost all Australasian *Anastatus*. However, males of different *Anastatus* species typically are distinguished by colour pattern and antennal structure, and these features likely will differentiate males of *A. eurycanthea* from those of other regional species. The description given above includes features that differ among at least some regional species based on examination of unidentified males from Australia.

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